U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 20.

WASHED SOILS:

How to Prevent and Reclaim Them.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE ASSISTANT SECRETARY,
Washington, D. C., October 27, 1894.

SIR: In accordance with your direction I have the honor to transmit herewith for publication a bulletin upon "Washed soils: How to prevent and reclaim them," prepared under my direction, by the Divisions of Chemistry, Soils, Forestry, and Botany, for one of the series of Farmers' Bulletins of this Department.

Thousands of acres of land in this country are abandoned every year because the surface has been washed and gullied beyond the possibility of profitable cultivation. It is believed that the present bulletin, and the simple facts therein presented as to how this erosion, or washing, may be prevented, and how washed and abandoned lands may be reclaimed, will serve a useful purpose in the hands of those farmers who have these trying problems to contend with.

Very respectfully,

CHAS. W. DABNEY, JR.,
Assistant Secretary.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

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WASHED SOILS: HOW TO PREVENT AND RECLAIM THEM.

THE EROSION, OR WASHING, OF AGRICULTURAL SOILS.

The denudation, or washing, of lands of the higher levels of the earth's surface is a process which no human precaution can wholly prevent. It has been one of the most important forces and factors in the geological changes which have so modified the surface of the earth. The present surface of the largest portion of the United States is made up of this "sedimentary" or "drift" material which has been moved from the place where it was formed through the disintegration and decay of the old crystalline rocks, by water, wind, or moving ice, and which has accumulated to a depth of hundreds or thousands of feet over nearly the entire surface of the country. It is estimated that the general surface of the land in the area of the crystalline rocks of the Piedmont Plateau has been lowered at least 2,000 feet by this continual washing. This vast amount of material has been slowly removed and deposited elsewhere by the very same agents which we are contending with to-day in our gullied fields; for this denudation, or erosion, is still going on, as it has been for ages past.

As a rule this denudation is exceedingly slow and the general level of large tracts of country is not lowered more than an inch or two in a hundred years. Where the change is as slow as this it is undoubtedly of benefit to the human race, as in the course of time it must carry off the soil which has been used over and over again for vegetation and expose fresh material to the roots of plants. With this slow change the natural forces are amply sufficient for the decay of the subsoil and for the conversion of this freshly exposed material into a good soil. When the rate of denudation is excessive, however, and more rapid than the natural decay of the subsoil material which is exposed, it may work serious injury to agricultural lands.

Along the banks of the Ohio River and in very many portions of the South hundreds of fields that were once covered with sturdy forests of oak, maple, walnut, and pine, and which bore under cultivation, after being cleared of the natural growth, large crops of wheat, maize, tobacco, and cotton, may now be seen furrowed with gullies as with the wrinkles of age, and abandoned to brush and briers.

A surface layer of good agricultural soil 6 inches deep resulting from the slow and gradual disintegration and decay of rocks and accumulation of humus may have required hundreds of years for its natural formation, and yet it is liable to be washed away in a single storm.

This excessive erosion, or washing, of lands may be prevented, and the already gullied fields may be recovered, and steep slopes of loose material may be held and prevented from washing—

(1) *By chemical means*, in the application of manures and fertilizers and in the accumulation of organic matter, which change the texture of the soil and make it more porous and more absorbent of water, so that there is less to run off over the surface.

FIG. 1.—An eroded field in the South.

(2) *By means of cultivation and underdrainage*, which prevent erosion by distributing the surface flow over the ground and increase the amount carried off by underdrainage.

(3) *By reforestation*, or the planting of trees, which act mechanically to prevent washing.

(4) *By grass and similar vegetation*, which bind the soil grains and prevent their washing away.

The erosion of a soil is caused by the wearing of the rain and snow waters which can not penetrate into the soil fast enough to be carried away by underdrainage, and which, by reason of the slope or contour of the land, run off over the surface, carrying along particles of sand

and clay. When this water accumulates in a depression in the field the force of the torrent may be sufficient to cut out a great gully in a short space of time.

The extent of washing to which the soil is exposed depends upon the quantity of rainfall in a given time, the slope or contour of the surface, the texture of the soil, the vegetative covering of the surface, and the kind and condition of cultivation. A soil composed chiefly of moderately coarse grains of sand, and having good underdrainage, will absorb the heaviest rainfall without much danger of surface erosion.

FIG. 2.—Another effect of erosion.

A clay soil, on the other hand, into which the water can not percolate with anything like the rapidity of the precipitation, will be washed and gullied by the torrent of water which must flow over the surface.

CHEMICAL RELATIONS OF THE SOIL TO SURFACE WASHING.

It has been repeatedly shown by experiments and by the experiences of farmers that a soil, as a rule, absorbs water more readily as the content of organic matter and of humus increases. Surface erosion can, therefore, be largely prevented by such a system of cultivation and cropping as will introduce as large a quantity of organic matter into the soil as possible. A very old method of recovering washed and gul-

lied lands is to place straw in the furrows while plowing, the straw not only acting mechanically to hold the soil in place and prevent surface erosion, but also in a very efficient way to increase the quantity of humus, thus making the soil hold large quantities of water which otherwise would have passed off over the surface. In this simple way fields which have been badly washed and gullied and entirely abandoned may be recovered and made highly productive.

The most important thing in the recovery of waste fields is the incorporation of organic matter of some kind in the soil; pea vines, stubble, briers, or leaves from the forest may be used as a source of the organic matter. The straw from one acre of land which has been recovered, as mentioned above, will be sufficient to start the recovery of another acre, even if this be deeply furrowed with gullies. Where enough organic matter can be used as a surface dressing, this layer helps greatly to retain water and to make the underlying soil more absorbent.

As soon as a sufficient supply of humus has been accumulated and the lands are brought up to an adequate condition of fertility, clover or grass should be seeded, if the land is at all suited to these crops, or rye, oats, or field peas should be sown to help hold the surface. Little by little, but more rapidly than would be expected from the forbidding aspect of the field, the land can be reclaimed again and made productive through the accumulation of humus and organic matter. A soil containing a fair quantity of humus will wash less readily than one nearly destitute of this matter.

A soil containing a fair supply of lime is much less liable to wash than one similarly situated and exposed which is deficient in lime. The reason of this is that clays which are deficient in lime, when once brought into suspension by moving waters, will remain in suspension and keep the water turbid for a long time. Clays which are heavily impregnated with lime salts, on the other hand, are in a flocculated state, the fine grains of clay being held together and in contact with the larger grains of sand. This flocculated mass quickly settles and is originally not so easily disturbed and carried off by moving water. A field treated with an abundance of lime is thus less easily washed by heavy rains. The results of investigations by Schulze, Sehloesing, and Hilgard have shown in a most emphatic way the beneficial changes which take place, especially in stiff clay soils, by the application of lime.

The change in the physical condition of the soil which is produced by the lime, and which is likewise produced by a number of other chemicals ordinarily used in commercial fertilizers, is another important factor worthy of consideration. A stiff clay soil is practically impervious to the penetration of surface water when it is delivered in such torrents as we are liable to have in our summer storms. A well-limed soil, on the contrary, although it may contain as much clay but in which the particles are flocculated or drawn together, is much more

pervious to water, and the amount of water which the soil will carry down through underdrainage is increased, and the excess which has to flow off over the surface is diminished. The surface washing of cultivated fields, especially those which are naturally deficient in lime, can be greatly diminished, therefore, by the free application of this substance to them.

A number of the ordinary fertilizing materials have an important effect upon the texture of soils and upon the permeability of soils to water, but few systematic investigations have been carried on in this line and not much, except of local importance, has been definitely settled by experiments or by the experiences of farmers.

WASHING OF LANDS MAY BE PREVENTED BY METHODS OF CULTIVATION AND UNDERDRAINAGE.

The depth and character of the tillage are very important factors in the washing of lands. A field in a condition of fine tilth and plowed to a depth of 10 inches will hold 2 inches of rainfall and absorb it very readily, and a soil in such a condition will suffer no surface washing from any ordinary rainfall. Where it is possible, therefore, land which is apt to wash should have the soil gradually deepened and be kept in a fine state of tilth so as to increase the storage capacity for excessive precipitations. This will not only save the surface from being washed and gullied, but it will also increase the store of moisture held by the soil, which is of very great value in the time of drought.

It is important also for this, as for other reasons, that the soil be covered with vegetation as much as possible throughout the year, as the roots and organic matter serve to bind the grains of the soil together. In some parts of Holland the drifting sands of the coast, which shift their position with every storm, often cover up valuable farming lands. Vast areas of these sands have been reclaimed and made productive by being covered with vegetation, while the roots and remains of organic matter hold the soil grains in place and prevent them from drifting and covering up more valuable lands. Any crop which requires very clean culture, as for example, cotton, is exhausting to the land for the reason that constant exposure of the surface to the sun and storms uses up the organic matter, makes the soil less porous, and the soil particles themselves are more easily washed away; so that, this clean cultivation is in its effects very favorable to excessive erosion. With crops which require such clean cultivation it is very advantageous to sow some crop like rye in the field during the last working of the crop both to bind the surface and protect it from washing in the winter and for other benefits which such a covering provides.

Another very effective method, when properly carried out, to prevent the washing of lands is to underdrain the soil with tile or other drains. These drains carry off quite rapidly an excess of moisture, so that much more of the rainfall is absorbed by the soil and carried off

through the drains and less washes over the surface of the land. Not only this, but a well-underdrained field is usually dryer and more porous, and has a greater capacity for absorbing the excessive rainfall and thus preventing surface washing. A field thoroughly underdrained with tile drains will carry off the water of any ordinary rainfall without any surface erosion. This method is very effective, but is likewise very expensive, and can not be used economically in extensive farming solely for this purpose of protecting the land from washing.

While the land may thus be made more porous and more absorbent of water—through the increase of the amount of organic matter or of humus, through the use of lime and other fertilizing material, through the deepening of the soil by gradually increasing the depth of cultivation, by so cropping it that it shall be covered with vegetation as much of the year as possible, and by underdraining the land—still, these methods may not be sufficient to so change the chemical and physical texture of the soil as to enable it to absorb the rain as it falls and to prevent an excess of water washing and eroding the surface where the contour of the land is such as to promote erosion from the surface flow of the excess of water.

It will be necessary in this case to provide for a more uniform distribution of the flow over the surface, and to prevent any accumulation of water which would have the effect of a torrential stream. This is secured in a great measure by laying off the rows according to the contour of the surface, so that each row will have a very slight incline of not more than from 1 to 6 inches in 100 feet, and in which the flow of water would be so slow that there would be little or no erosion. Theoretically, this is a fine idea, to let each row carry off its own proportion of the excess of rainfall so gently that there shall be no erosion, thus acting as a minature drain. Practically, however, it is often impossible to keep these rows from breaking through, and when the bed is once broken and the water overflows into the next row the accumulation of water is sufficient to break down bed after bed until the rows from all the field are discharging into this narrow channel.

To overcome this difficulty sidehill ditches may be used in which larger and more substantial ditches are provided, following very nearly the contour of the field, so that there shall be a fall of from 1 to 6 inches in 100 feet. The distance apart of the ditches will depend upon the slope of the field; with a very steep slope they should be close together, often not over 6 to 10 feet apart; with a gentle slope they should be at intervals of 15 or 20 feet, or even farther apart, depending upon the texture of the soil and the contour of the surface.

These sidehill ditches are very easily constructed, being made almost entirely with the plow. A bank is formed by running a number of furrows, throwing the dirt toward the middle. The last furrow on the upper side is cleaned out with a spade to form the bottom of the ditch. If the plow is well handled it takes very little

work with the spade to make a very substantial ditch. It is well to get the bank forming the lower side of the ditch sodded with grass to help hold it and to lessen the danger of its giving way during a heavy rainfall. When the slope is thus protected with a number of ditches at the proper distance apart, the rows can be given a rather steeper fall so that they shall run out into the drains at frequent intervals and not have to carry the water so far. These ditches have to be constructed with care and have to be strengthened where they cross any depression or sudden curve by building up an embankment with sticks and brush thrown across to support the embankment. Unless these ditches are thoroughly constructed they are worse than useless, for if they break they concentrate a volume of water upon one point in the field which would otherwise have been distributed over the surface, and this often forms a torrent which does great damage.

Fig. 3.—Showing construction of sidehill ditches.

It is essential that these ditches and rows be run according to the contour of the surface of the land, and that there shall be no low places where the water would accumulate and gather force. They should always be run with a level, of which there are several forms on the market suitable for this work.

A more efficient, but at the same time much more expensive, method of preventing the washing of lands where there is a considerable slope, is to terrace the fields so that there shall be level steps upon which the water can rest for a while and be absorbed. In terracing the lines are run with a spirit level following the contour of the surface so as to give a perfectly level line. A furrow is run along this line, and a similar furrow is run along a lower contour, the distance apart depending upon the nature of the land and the slope of the surface, as in case of sidehill ditches. Theoretically, it is intended to have the surface between these two furrows level so that there will be no chance for the water to run off over the surface. On a small scale this leveling can be done with a horse shovel, and the land thus put at once into a condition to pre.

vent washing. In this case the banks of the terrace are sodded or seeded with grass to prevent them from washing. In field practice, however, the soil is moved gradually with a plow, the furrow being thrown always downhill and the soil gradually worked down to a level plain. There are several forms of reversible plows which are admirably adapted to this purpose, being turned readily from a right to a left handed plow, so that in going back and forth the furrow is always thrown downhill. It requires, of course, a number of years of such cultivation to get the surface into even approximately a level condition, but with patience and thorough cultivation the soil very quickly assumes a comparatively level aspect, and erosion is reduced to a minimum. This is a more expensive method, but if intelligently done it is much more efficient and much more durable than depending upon sidehill ditches to prevent erosion. As was said in the case of the sidehill ditches, unless this work is well done it had much better be left undone, as it may seriously injure the field.

FIG. 4.—Showing method of terracing farm lands.

Where erosion has proceeded so far as to render the land at present unfit for cultivation, or where the land is not needed for cultivation and it is desired to prevent erosion, the land should be given up to trees, herbs, or grasses of some kind according to one or the other of the following methods.

RECOVERING GULLIED HILLSIDES BY REFORESTATION.

Forest ground is not subject to this erosive action of the rainfall because in a forest a large part of the rainfall never reaches the soil, as 20 or 30 per cent is intercepted by the foliage and evaporated before it reaches the ground. The rainfall which reaches the surface is rapidly absorbed, as the soil is kept granular and loose and much more of the water is carried off by underdrainage rather than by surface drainage.

The forest covering protects the soil in the following ways:

(1) By preventing rain from falling directly upon the soil, the foliage

of the tree crowns intercepting and breaking its force, the water reaching the soil more gently from the leaves and along the branches and trunks of the trees.

(2) By interposing a loose cover or mulch of litter formed by the fallen leaves and branches, which breaks the direct force of the raindrops and keeps the soil from being compacted or puddled by their blows.

(3) The deeply penetrating roots, and holes left from decayed stumps and roots of trees, assist in this underground drainage.

(4) The litter with the stumps and projecting roots and trunks of trees prevent the water from rapidly running over the ground and from gaining the momentum and force which is necessary in order to erode and gully the soil.

(5) The forest cover prevents the drifting and the rapid thawing of snow, thereby insuring more even distribution of the waters and an increase in the time during which it can percolate or be absorbed into the soil.

If the forest floor is not disturbed by fire, nor the litter trampled and compacted by cattle, it always reduces rapid surface drainage and largely, if not entirely, prevents erosive action.

RECOVERY OF WASHED SOILS.

Just as deforestation of hillsides and hilltops is the first cause for inducing erosive action, so is reforestation the most effective means in curing the evil. This has been demonstrated in France, where the Government and the farmers together have spent, during the last thirty years, over $40,000,000 and expect to expend three or four times that amount to reforest 1,000,000 acres of denuded mountain sides, the soil and débris from which has been carried by the torrents of water into the plain, covering over 8,000,000 acres of fertile ground and making it useless for agriculture. Sodding for pasture has been found mostly less effective and on the steeper slopes entirely ineffective.

Wherever the ground in the hill country is not fit for agricultural use it should be set and kept in forest, not only to make it produce a timber crop, but also to prevent the erosion which finally becomes dangerous to the lower valley lands. Wherever agriculture is possible and profitable there should be such a distribution of forest, pasture, and field as will secure the greatest immunity from erosive and torrential action of the waters. The forest should occupy all hilltops which, as a rule, have too thin a soil to allow profitable agricultural use; it should be kept growing on the steeper slopes where the water acquires the greatest momentum and the loosening of the soil by the plow furnishes a most favorable condition for erosive action; it should be placed on all rocky, uneven, agriculturally useless spots, because it will produce useful material even on such unfavorable situations, and, finally, forest belts should be maintained on long slopes alternately

with fields and pastures, running along the brow of the slope of widths and at distances proportionate to the character of the land and the angle of the slope—on the steeper slopes closer together, on the gentler slopes further apart. These belts, acting as a barrier to break the force of the water, will prevent an undue accumulation of surface waters and will protect to a considerable degree the lower fields from washing. Farmers, therefore, living in the eroded hill country should start upon the work of reforestation with a well-conceived plan. They should determine beforehand which parts ought to be in forest, and which they may reasonably expect to adapt again to agricultural uses. They should understand that they must begin this work at the origin of the evil, at the very tops of the hills where the water begins to gather and acquire its force, and gradually proceed with their work down to the lower levels.

PREPARATION FOR PLANTING FORESTS.

Although cultivation of the soil for tree planting in the manner practiced for field crops is advantageous to the young plants for the first few years of their life, it is by no means necessary, and rough, broken, and stony ground, which could not be plowed and prepared for ordinary field crops can be readily planted in trees. If the ground is in such a condition that it can be plowed, this is decidedly the best method of preparing the land. The plowing should in all cases follow the contour of the hill and be as deep as possible, in order to allow as much water as possible to soak into the soil and so diminish surface erosion and prevent the young trees being washed out. The occasional gullies must be filled with brush and soil, or stones, rubble, and dirt.

In the deeply gullied hill lands, where plowing has become impracticable, other ways must be provided against the further erosive action of the water, which would otherwise be apt to wash out and uproot the plants. For this purpose it is necessary to break the force of the water by constructing brush dams across the gullies, and roughly fill in the latter with stone, gravel, earth, etc., in front and rear if they are shallow, and at least in the rear if they are deeper. Where the ravines are especially deep and wide it may become necessary to supplement and strengthen the rough dam with a loose rubble embankment or a dry wall of stone. A simple and efficient method has been practiced in France, which consists in filling up the ravine with brush placed lengthwise and keeping this down by poles laid across and fastened in the sides of the ravine. The waters are thus allowed to drain off, while the soil carried by them is retained in and over the brush, and in a short time the gulley will fill up of its own accord. Then alders and willows are planted along the edge and soon finish the work of securing the ravine against washing. The means for thus breaking the force of the water in the gullies and changing it from a rushing torrent into a series of gentle falls, and in part from surface drainage into subterranean

drainage, and of filling up the gullies themselves will have to be devised in every special case as circumstances permit and the ingenuity of the operator suggests. The brush dam is preferably made of willow, poplar, alder, or other readily sprouting material, which becomes alive and by striking root adds to the firmness of the dam.

It is especially needful, as in all kinds of dams, to fasten the ends securely. According to the steepness, depth, and width of the ravine more or less frequent dams are necessary. The accompanying illustration shows how such work is being done successfully in France. After the brush dams, walls, and other breastworks have been established, the waters may be allowed to do the work of filling up the gullies themselves, which they will do sooner or later, or else, where it can be readily accomplished, the filling may be done by hand.

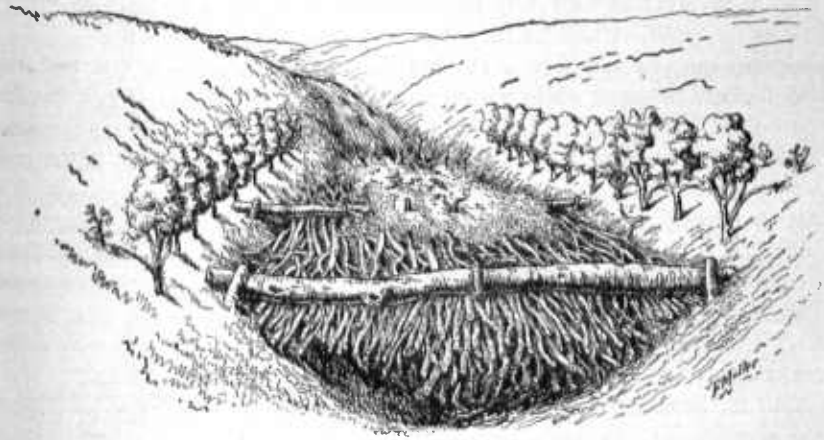

FIG. 5.—Construction of a brush dam.

It must be understood that unless this preliminary work is well done and systematically, beginning at the very tops of the hills where the waters start, it is not worth doing at all, since the water if allowed to get headway would soon wash away and destroy any imperfect work.

PLANTING.

To cover the soil as quickly as possible with a dense and permanent arborescent cover is the object to be attained. Where the soil has not been so far eroded that plowing could be done, it might be best for the first season to sow oats, field peas, or other crops that will readily grow and make a cover. This may be cut for green fodder, leaving a high stubble, and tree seed can be sown broadcast with the fodder crop in the early summer, or over the stubble after the crop is cut in the late summer and fall. The cheapest and most readily germinating tree seed should be looked for and the quantity used per acre should

be lavish, to secure a dense stand from the first. The most readily available kinds are the silver or red maple, box elder, elms, ash, and black locust; and since for various reasons variety or mixed woods are preferable, it is advisable to use as many kinds as can be readily obtained.

The soft and red maples ripen their seed in early spring, just about when the leaves are at full size, and should be gathered and sown immediately, as they spoil in a short time. Sown with a field crop they will make a good growth the first year, benefited by the shade of the crop. To provide amply for loss by failure and by destruction when reaping the field crop, not less than three to four bushels per acre of the winged seed should be sown.

The elms ripen their seed in the early summer, by the end of May or beginning of June. As they spoil in a few hours, if allowed to heat in bags, they must be carefully handled and be sown soon after ripening. The same quantity should be sown as of the maples, or somewhat more, and they may be sown after the maples. The box elder is a very hardy and densely foliaged plant which ripens its seed in the early fall. They should be sown soon after ripening at the same rate as the maples. Of the several varieties of ash, the green and white are to be recommended, especially the former, which bears fruit early and plentifully, and is perhaps more hardy than the white. The latter is, however, superior in its timber. The seed ripens by the end of September and the beginning of October, and although it will keep over winter, it is best sown soon after gathering, when the rains and winter snows will carry it through the stubble to germinate next spring.

Finally, with a view to adding a more valuable species, which at the same time is readily procured and propagated, the black locust should be introduced. The seeds ripen in July or August and have the advantage of keeping readily in good condition, and may therefore be sown at any time, but are best used soon after ripening. This species should never be planted alone, because it does not shade the ground well, but when mixed with other shadier kinds, which by their fuller foliage give better soil protection and at the same time reduce the danger from the borer, to which the black locust is otherwise liable, it is one of the most useful species for the purpose, because it grows readily and quickly and suckers and sprouts vigorously, thus insuring a continuous soil cover. With a tolerably dense cover of other species assured, an addition of one or two pounds per acre of locust seed will greatly enhance the economic value of the plantation.

Where the ground is too much cut up and too uneven to permit of plowing, recourse must be had to sowing of seed in plats, or planting of seedlings or cuttings by hand. This is naturally much more expensive, and therefore should be done with greater care and foresight. Plats may be made by loosening the soil with a hoe or spade, and sowing the seed into these seed beds, covering the seed only slightly. The

plats should be 3 to 4 feet apart to make sufficiently rapid cover. The success of this method is, however, very questionable, as not only the germinating of the seed under the prevailing conditions is precarious, but rains are apt to wash out the seed or young seedlings. The best success may perhaps be obtained with black locust or oak, the seed of which can be placed deeper (1 to 2 inches) according to soil conditions, with a hope of germinating and avoiding the danger of washing. The surer method, however, will be found in planting seedlings or cuttings. Seedlings are not only expensive but also more precarious to handle, hence for the bulk of the plantation such kinds as can be readily obtained and propagated by cuttings are used, and if desired a sufficient number of seedlings of better kinds can be added to increase the timber value of the plantation.

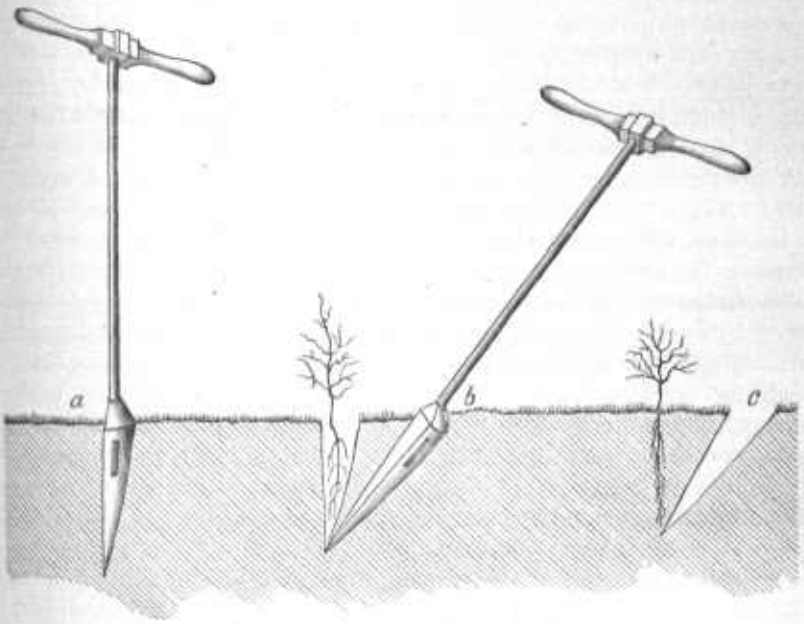

FIG. 6.—A dibble used in planting trees.

The cheapest and most readily growing material for the general cover is furnished by the willows and poplars, to which may be added the box elder, the black locust, and the catalpa, while other more valuable kinds may be introduced, when the first cover has been established, by the planting of 2 or 3 year old plants in single specimens.

The cuttings are best taken in winter before vegetation begins (before the 1st of March), and should be laid in water until planting time, in April; they should be cut 14 or 16 inches long from 3, 2, or even 1 year wood, if of good size, and preferably from the main shoots. For planting, an iron dibble with handle, somewhat like that shown in Fig. 6 is used, and a half conical shoe 12 inches long and $2\frac{1}{2}$ to 3 inches in

diameter is also a useful instrument. If the soil to be planted is rather compact and hard, a step may be added—to be used like a spade. The dibble is thrust into the ground to its full depth, loosened and withdrawn; a boy holds the cutting into the hole so that about two or three buds remain above ground; a second thrust somewhat slanting, 2 inches or so from the first hole, and a forward movement closes the hole and plants the cutting, while a few additional short thrusts close the last hole. Two skillful men, with a boy to serve both in placing the cuttings, can plant 3,500 in a day. Seedlings, of course, are planted in the same way.

The first and principal object being to break the force of the surface waters, the arrangement in setting out the plants should be as nearly as possible in horizontal and parallel rows along the brow of the hill, following the contours. To get a full cover as soon as possible the plants should be set not farther apart than 3 to 4 feet and even less, making from 5,000 to 7,000 per acre. If this is found too expensive, or for some reason impracticable to be done at once, the work may be reduced and divided into several seasons; the rows then may be made farther apart, say from 6 to 16 feet, according to the slope, and the plants in the row 2 feet, when the number will be one-half, or less. Additional rows and perhaps of better classes of timber, especially oaks, chestnuts, tulip trees, ash, walnut, and others may be introduced in the following seasons, the soil having come to rest by the first plantings; or else the trees and shrubs grown in the first rows can be utilized to establish a cover by layering their branches. This is done simply by bending down branches, fastening them to the ground by small wooden forks or clamps, and covering a part, say 6 or 10 inches from the end, with soil, when they will strike root and the next year the bent-down branches may be cut loose from the new stock. The branches must be covered with enough earth to insure that sufficient moisture is at their disposal for root formation; covering the buried part with a sod or a stone, which prevents evaporation, is advantageous.

Whatever is done in such a work of recovering lost ground, let this fact never be forgotten, that it is better to do a small part well than a large part indifferently, which usually means lost labor.

GRASSES AND SIMILAR VEGETATION PREVENT EROSION AND WASHING OF AGRICULTURAL LANDS.

On gentle slopes a good turf of perennial pasture grasses, especially those with creeping rootstocks, prevents erosion, or washing, of lands, and short steep embankments may also be protected with this same covering. On longer and steeper slopes, however, this method is not so effective as that of reforestation.

In enumerating the effects to be obtained by the growth of grasses and other herbaceous vegetation on washing lands, or lands liable to

be eroded, it should be stated that such growths are calculated to break the force of the rainfall and prevent its packing the soil; to render the ground more porous through the root penetration into the subsoil; to make the soil more absorbent and more retentive of moisture through the addition of humus to the soil from the decay of the plants; to retard the rate with which the surface waters flow off, and lastly, to bind the particles of soil together, which is especially effective in the case of light sandy lands and of newly formed embankments, whether of sand or clay.

The turf which would answer the present purposes should be composed of perennial grasses of varieties which have creeping rootstocks, and it is frequently essential that they be able to grow upon an impoverished and often hard soil. To secure a strong turf on lands of this character it is very important that the soil be put into the best possible condition. Where practicable the soil should be thoroughly plowed or loosened, and some variety of field pea or clover be seeded down, such as the cowpea, Japan clover, or the crimson clover, all well adapted to this purpose. These crops may either be cut off, leaving a high stubble to be turned under, or the whole may be plowed under, thus furnishing a quantity of organic matter to the soil as a preparation for the grasses which are to be seeded. As drought is one of the most serious conditions to be contended with on lands of this character, crimson clover is one of the best of these green manuring crops, as it makes most of its growth in the winter months, when there is less liability of drought. This, however, can not be used too far North, as it does not stand the winters well.

With this preparation of the soil Bermuda grass is one of the best grasses for the purpose of preventing erosion, or of reclaiming eroded land in the South. This should be planted by cutting up a turf rather than by seeding, as the seeds do not germinate very readily, even where they have been gathered in a mature condition. Care must be taken in the introduction of this Bermuda grass, as it is exceedingly troublesome in the cotton field. In the North the English blue grass is one of the best grasses for this purpose, and the Hungarian brome is valuable for the same purpose in both localities.

Where the soil will support other good turf grasses of higher value for hay or pasturage, or where the soil can be brought into a condition to support them, these more valuable grasses should be introduced.

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